APPENDIX B

REFERENCE APPROACH

B1. REFERENCE CONDITIONS

B1.1 Reference Conditions as Defined Within Appendix A of the State of Montana 303(d) List (MDEQ, 2004)

MDEQ uses the reference condition to determine if narrative water quality standards are being achieved. The term “reference condition” is defined as the condition of a water body capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a water body’s greatest potential for water quality given historic land use activities.

MDEQ applies the reference condition approach for making beneficial use-support determinations for certain pollutants (such as sediment) that have specific narrative standards. All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental or injurious. These levels depend on site-specific factors, so the reference conditions approach is used.

Also, Montana water quality standards do not contain specific provisions addressing nutrients (nitrogen and phosphorous), or detrimental modifications of habitat or flow. However, these factors are known to adversely affect beneficial uses under certain conditions or combination of conditions. The reference conditions approach is used to determine if beneficial uses are supported when nutrients, flow or habitat modifications are present.

Water bodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. It attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil and water conservation practices. MDEQ realizes that presettlement water quality conditions usually are not attainable.

Comparison of conditions in a water body to reference water body conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the TSS of a stream at base flow during the summer should not be compared to the TSS of reference condition that would occur during a runoff event in the spring. In addition, a comparison should not be made to the lowest or highest TSS values of a reference site, which represent the outer boundaries of reference conditions.

The following methods may be used to determine reference conditions:

Primary Approach

- Comparing conditions in a water body to baseline data from minimally impaired water bodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Evaluating historical data relating to condition of the water body in the past.
- Comparing conditions in a water body to conditions in another portion of the same water body, such as an unimpaired segment of the same stream.

Secondary Approach

- Reviewing literature (e.g. a review of studies of fish populations, etc. that were conducted on similar water bodies that are least impaired.
- Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the water body's fisheries health or potential).
- Applying quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

MDEQ uses the primary approach for determining reference condition if adequate regional reference data are available and uses the secondary approach to estimate reference condition when there are no regional data. MDEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

B.1.2 Reference Approach for the Ruby TPA

B.1.2.1 Internal References

Reference areas, or "least impaired" reaches, were selected based on stream assessment (SRAF) score, natural vs. human-caused sediment inputs, bioindicators, canopy cover on streambanks, Rosgen stream type departure analysis, bank stability score, and vegetation composition. The SRAF score was used as the primary indicator of condition because the SRAF provides the most comprehensive assessment of overall condition of any methods used in this analysis. The other factors were used to verify condition with more detailed information. Least impaired reaches were only selected from reaches with an SRAF score of greater than 85. Selecting reaches scoring at least 85 includes the top 15th percentile of reaches as reference areas. Reaches in "Good" condition, scoring 80 or greater comprise the top 25th percentile of reaches, but may exhibit some significant influences of land use affecting sediment or other pollutant levels. Generally, reaches scoring 85 or more were more indicative of natural conditions. Using the top 15th percentile for the SRAF score incorporates a margin of safety in selecting reference areas, which is necessary when semi-quantitative measures are being used for determining reference values. As an additional margin of safety, reaches scoring over 85 on the SRAF but not displaying reference condition based on the other factors are not used as least impaired reaches.

Table B-1 lists the reaches in each management area (landscape) and the reference reaches applicable to the unique landscapes of the Ruby River watershed.

Table B-1. Stream Assessment Reaches and Management Areas.

Management Area	**Water Bodies**	**Assessment Reaches in Management Area**	**Reference Reaches (least impaired)**
Snowcrest	Shovel Creek Hawkeye Creek West Fork Ruby Middle Fork Ruby	All reaches on these water bodies	MFR3A, HAW1B
Gravelly Range	East fork Ruby Warm Springs Burnt Creek Basin Creek Coal Creek	All reaches on these water bodies	BAS3A, COA3A
Ruby Range	Mormon Creek Cottonwood Creek Garden Creek	All reaches on these water bodies	None
Sweetwater	Sweetwater Creek	All reaches on these water bodies	SWC4E
Upper Ruby River	Ruby River 3 forks to Reservoir	All RRU reaches	RRU5J
Lower Ruby River	Ruby River below Reservoir	All RRL reaches	CCKB, RRL4M
Tobacco Root Range	Mill Creek Indian Creek Wisconsin Creek Ramshorn Creek Currant Creek California Creek	MIL-B, MIL5C, MIL5D, MIL4A IND6C, IND6B, IND7A WIS5D, WIS6C, WIS7B, WIS8A RAM5C, RAM5D, RAM-NF, RAM 6B CUR2A, CUR1B CAL4F	IND6B, MIL5D, MILB, WIS7B, WIS6C, WIS8A
Pediment below TobaccoRoots/Urban influence	Mill Creek Indian Creek Wisconsin Creek Ramshorn Creek California Creek Harris Creek	MIL3G, MIL2H, MIL2H.2, MIL3F, MIL3E IND4E, IND4D, IND5C.2 WIS4E, WIS3F, WIS3G, WIS2H RAM4E CAL3C HAR1A	IND5C2
Alluvial Valley	Mill Creek Indian Creek Wisconsin Creek Ramshorn Creek California Creek Alder Creek	MIL2I, MIL1J IND3G, IND2H, IND3F.2,IND3F WIS2I, WIS2J, WIS2K RAM2F CAL2E, CAL2A, CAL2B, CAL2D ALD1A, ALD1B, ALD2C	None
Greenhorn/Tobacco Root Range	Alder Gulch Browns Gulch North Fork Greenhorn	All reaches for these water bodies except ALD1A, ALD1B and ALD2C	NFG1A

Table B-2 summarizes conditions on the best available reaches in the Ruby River. These "reference" reaches are not considered pristine condition, but provide a basis for comparison with areas in which land use has not impaired beneficial uses. The reaches are all on the study streams, and therefore are from least impaired areas of listed or recently delisted water bodies. Reaches exhibiting a departure for high fine sediment are not included in this table of reference reaches, even if they are considered the best available condition for their given landscape in Table B-1 (above field ref table).

Table B-2. Ruby Watershed Reference Reaches (Least Impaired Reaches).

Stream Reach	Stream Type[1]	W/D	Entrench	Sinuos	% Slope	% Wol <2mm	49 pt grid	BEHI	Avg Residual pool depth	% Canopy cover	Riparian Belt Width (ft)	% Stable bank
WIS6C	B4	29	1.6	1.0	4.2	13	8	11.9	0.84	80	40	75
BAS3A	B4a	14	1.8	1.1	>4	18	20	26.5	0.03	40	35	65
COA3A	B4a	23	1.4	1.2	>4	22	NC	20.3	0.93	60	60	40
IND6B	B3a	26	1.8	1.0	5	12	3	9.5	0.92	70	60	85
MIL5D	B3a	13	1.4	1.1	5	11	7	10	0.92	70	55	95
MILB	B3a	13	1.6	1.1	10	12	3	10	0.76	65	30	95
WIS7B	C3a(B3a)	23	3.33	1.1	6	9	NC	10.4	NC	85	80	85
IND5C2	C3a(B3a)	18	2.8	1.1	5.1	14	6	11	1.3	70	85	87
RRU5J	C4(E4)	28	2.4	1.7	<1	17	NC	11.8	NC	80	150	85
MFR3A	E4	2	4.7	1.1	1.7	29	NC	9.5	0.2	50	21	80
WIS8A	E4a	9	4.2	1.1	10.5	12	6	16.5	0.7	80	45	80

[1]Stream types in parentheses represent potential stream types, which may characterize portions of the reach.

Data from these reaches provide a basis for comparison with other reaches for parameters for which other quantitative data have not been collected.

B.1.2.2 Geomorphic Assessment using SW Montana National Forest Reference Site Data

Reference sites documented by the Beaverhead-Deerlodge National Forest (BDNF, n.d.) provide a basis for comparison of channel morphological features, including substrate surface particle size distribution, width/depth ratio and bank stability rating (BEHI).

Forest Service data for 137 reference sites were used as a basis for determining departure from reference geomorphic condition. The following geomorphic parameters were used as a basis of comparison among field reaches and Forest Service reference reaches of similar Rosgen stream types:

1) Width/Depth ratio
2) Entrenchment
3) Sinuosity
4) Slope
5) Percent Surface Fine Substrate (<2 mm and <6 mm)
6) Bank Erosion Hazard Index
7) Valley Bottom Width

Geomorphic departure analysis was conducted by comparing conditions existing in field assessment reaches to values from Forest Service reference reaches for the above parameters, averaged by level 1 stream type. Potential level 1 stream type is determined following methods outlined in Rosgen (1996), comparing valley bottom width, slope, and sinuosity determined from aerial photographs and 1:24,000 topographic maps to Rosgen guideline values. Geomorphic conditions of assessment reaches were compared to reference values for the same potential stream types to determine departure from expected conditions. Potential level 2 stream type and departure can only be accomplished through comparison to reference reaches and other reaches on the same water body within the same landscape. Additional information is gained from plots of particle size distribution and pictures. Ultimately, level 2 potential stream type relies on "Best Professional Judgment" taking the natural setting into consideration.

An unpublished dataset including data for 137 reference reaches in southwest Montana was used for departure analysis. Table B-3 summarizes average values of these parameters for each reference stream type, derived from BDNF data. It should be noted that a high degree of variability exists in natural conditions, and average values by stream type may not necessarily address all conditions naturally present in a watershed. However, these guideline values, when analyzed together, provide a useful baseline for determining the nature of geomorphic departure and can be used as part of a suite of indicators to determine sources of impairment. The sediment targets in the TMDL document are not based on the average, but on the 75th percentile of the reference condition for all the parameters except for entrenchment ratio, the 25th percentile is used.

Table B-3. Average Values for Geomorphic Attributes in BDNF Reference Reach Data, Listed by Stream Type.

Stream Type	W/D	Entrenchment	Sin	% Slope	BEHI	VBW
A	8.7	1.3	1.1	7.6	21.1	81
B	13.43	1.68	1.26	3.6	20.9	133
C	21.2	9.9	1.5	1	21.4	732
E	3.9	20.1	1.5	2.5	18.9	232
Ea	5.7	7.1	1.2	7.1	20.4	114

Percent fines less than 2 mm was generally lower than 10% for reference reaches, and could only be used in cases where fines less than 2 mm comprised over 10% of the substrate in field reaches to give a qualitative indication of excess fines. Percent fines less than 6 mm is derived from curves by level 2 Rosgen stream type, and provides more accurate information. A summary of average reference values used to determine departure is provided in Table B-4 (below). The dataset used to derive particle size distribution curves is larger than that initially used for level 1 departure analysis using other geomorphic parameters. Although the average reference condition is provided in table B-4, the 75th percentile of reference site conditions is used for setting targets in the TMDL. See next section of this appendix for further explanation of statistics used in target setting.

Table B-4. Reference Values from Average Percent Fines for Level 2 Stream Types in BDNF Data.

Stream Type	Sample Size	Reference Average % <6 mm
A3	7	< 10[1]
B2	4	25
B3	25	<10
B4	12	16
C3	12	<10
C4	23	17
E3	14	<10
E4	73	23

[1]USFS assessment do not extend below 10% fines.

B.1.2.3. Use of Statistics for Developing Reference Values or Ranges

Reference value development must consider natural variability as well as variability that can occur as part of field measurement techniques. Statistical approaches are commonly used to help incorporate variability. One statistical approach is to compare stream conditions to the mean (average) value of a reference data set to see if the stream condition compares favorably to this value or falls within the range of one standard deviation around the reference mean. The use of these statistical values assumes a normal distribution, whereas water resources data tend to have a non-normal distribution (Hensel and Hirsch, 1995). For this reason, another approach is to compare stream conditions to the median value of a reference data set to see if the stream condition compares favorably to this value or falls within the range defined by the 25th and 75th percentiles of the reference data. This is a more realistic approach than using one standard deviation since water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on the statistical summaries if a normal distribution is incorrectly assumed, whereas statistics based on a non-normal distributions are far less influenced by such observations.

Figure B-1 is an example boxplot type presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable then measured values above the 75th percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative water quality standards or developing numeric criteria is consistent with U.S. EPA guidance for determining nutrient criteria. Furthermore, the selection of the applicable 25th or 75th percentile values from a reference data set is consistent with ongoing MDEQ guidance development for interpreting narrative water quality standards where it is determined that there is "good" confidence in the quality of the reference sites and resulting information. If it is determined that there is only a "fair" confidence in the quality of the reference sites, then the 50th percentile or median value should be used, and if it is determined that there is "very high" confidence, then the 90th percentile of the reference data set should be used. Most reference data sets available for water quality restoration planning and related TMDL development, particularly those dealing with sediment and habitat alterations, would tend to be "fair" to "good" quality. This is primarily due to a the limited number of available reference sites/data points available after applying all potentially applicable stratifications on the data, inherent variations in monitoring results among field crews, the potential for variations in field methodologies, and natural yearly variations in stream systems often not accounted for in the data set.

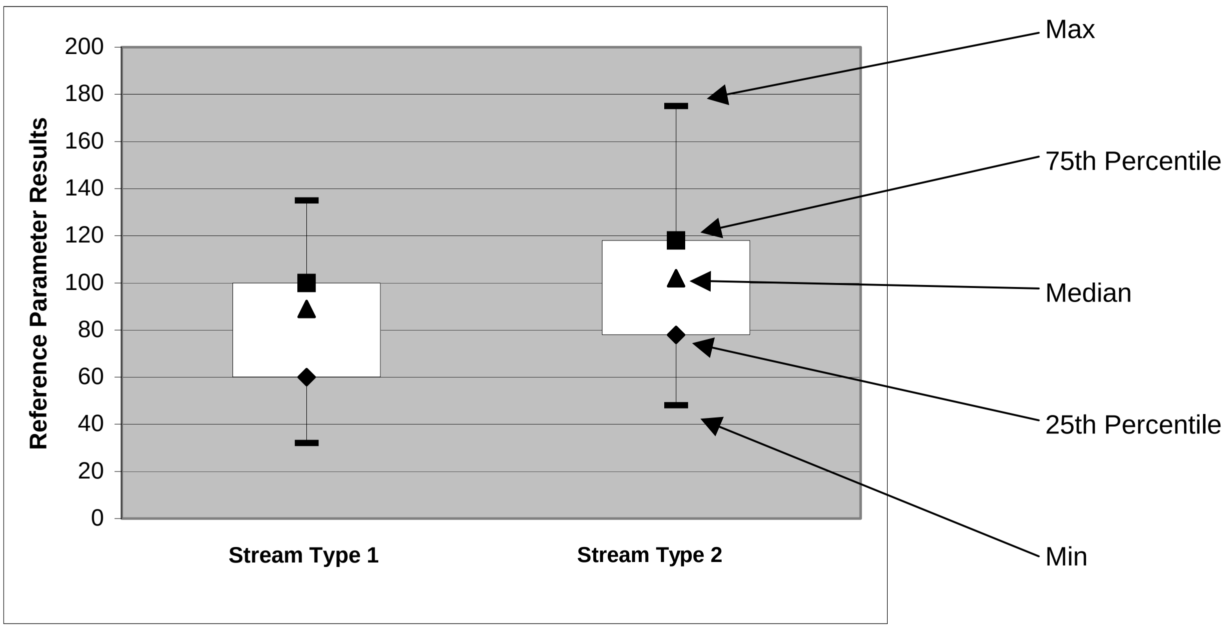

Figure B-1: Boxplot Example for Reference Data.

The above 25th – 75th percentile statistical approach has several considerations:

1. It is a simple approach that is easy to apply and understand.
2. About 25% of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.
3. About 25% of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25th to 75th percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition, as defined above in Table E-4, can be difficult, particularly for larger water bodies with multiple land uses

within the drainage. This is because all reasonable land, soil and water conservation practices may not be in place in many larger water bodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil and water conservation practices were not applied.

5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the water quality standards in Table E-4. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, cold water fish or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Figure E-2 shows example relationship between a parameter of concern and a beneficial use (aquatic life in this example). Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

As identified in (2) and (3) above, there are two types of errors that can occur due to this or similar statistical approaches where a reference range or reference value is developed. 1) A stream could be considered impaired even though the naturally occurring condition for that stream parameter does not meet the desired reference range. 2) A stream could be considered not impaired for the parameter(s) of concern because the results for a given parameter fall just within the reference range, whereas the naturally occurring condition for that stream parameter represents much higher water quality and beneficial uses could still be negatively impacted. The implications of making either of these errors can be used to modify the above approach, although the approach used will need to be protective of water quality to be consistent with MDEQ guidance and water quality standards. Either way, adaptive management is applied to this water quality plan and associated TMDL development to help address the above considerations. This adaptive management is further defined in later sections of this document.

Where the data does suggest a normal distribution or reference data is presented in a way that precludes use of non-normal statistics, then the above approach can be modified to include the mean plus or minus one standard deviation to provide a similar reference range with all of the same considerations defined above.

In some cases, there is very limited reference information and applying a statistical approach like above is not possible. Under these conditions the limited information can be used to develop a reference value or range, with the need to note the greater level of uncertainty and perhaps a greater level of future monitoring as part of the adaptive management approach. These conditions can also lead to more reliance on secondary type approaches for reference development.

B.3. References

Beaverhead-Deerlodge National Forest (BDNF). n.d. Unpublished Stream Morphology Data. Dillon, MT.

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